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formally: The condition of the state survey is likely to be materially influenced by the law of the general government extending the U. S. geological survey over the states. Proper deference to the head of the U. S. survey required that some action should be taken by which we could confer with Major Powell, to understand our relations to the survey. To prevent any jealousy or uncertainty with regard to what might be the relation of the state survey and the general survey, I suggested the appointment of this committee. I had no intention myself of taking any active part in the matter; and I think there are gentlemen on the committee, much younger than myself, who will do all the work. I believe several members of the committee have had very pleasant interviews with Major Powell, as I have myself, since these meetings commenced; but I had forgotten that I was to make a report. I think it is desirable that there should be very frank intercourse between the gentlemen who are conducting the state surveys and the head of the general government survey, so that we may know what is to be the result of their various surveys which are so very important to geological science. Workers at a distance from each other cannot, without some means of inter-communication,—which, I think, may be established with the head of the general survey,—bring the results of their labors to a fair comparison with those which are done a thousand miles away.

Major Powell expressed the hope that the committee would be continued. Several members of the committee had conferred with him with reference to the surveys, but they had not conferred as a committee. Practical relations have been established between the general survey of the United States and several of the state surveys. He thought it was probable that such arrangements could be established as would make it satisfactory to all.

The committee was continued.

## PAPERS READ BEFORE SECTION E.

### (PAPERS ON GLACIAL PHENOMENA.)

#### The life history of the Niagara river.

BY JULIUS POHLMAN OF BUFFALO, N.Y.

A SERIES of observations whose points were given in detail had convinced the author that the formation of the gorge of Niagara had been a matter of tens of thousands, rather than of hundreds of thousands, of years. The beginning of the history might be stated as in the pre-glacial epoch. A lake then occupied the valley of the Tonawanda; its outlet was the line of the ancient Niagara River from the falls to the whirlpool; thence, by way of the St. Davids valley, into the Ontario valley. All these valleys were closed during the glacial period. The subsidence of Lakes Erie and Ontario was that of one body or region, until they were separated by the Lewiston escarpment; after that the drainage of Lake Erie found its path through drift deposits

and old existing valleys to Lake Ontario. The latter lake subsided slowly, and no waterfall was formed at its entrance. The river excavated its gorge to the whirlpool, not by means of a retreating fall, but as a rapid in an old shallow valley. At the third pool, this path met the ancient river-valley: it was along that valley only, that the falls receded to their present site. The retreat of the fall was not the means of excavation, for at least seven miles usually ascribed to it; the portion which would offer the most resistance, between the falls and the whirlpool, being already excavated.

From that point to Lewiston, the progress was very rapid in cutting the gorge; a shallow valley had partly removed the hard limestone, and the softer underlying shale rock was a barrier much more easily penetrated. We have no exact data of the retrocession of the falls within periods of modern observation. A comparison of Professor Hall's map of the falls in 1841, and that of the United-States lake survey in 1875, shows wide discrepancies. After all reasonable allowance for inaccuracies, we must admit that parts of the Horse-shoe fall have receded in thirty-four years at least one hundred feet, and on the American side the recession is from twenty to forty feet. These facts all tend toward a shortening of the history of the present river.

In the discussion that followed, Professor Hall expressed a doubt as to the dependence that could be placed on differences between surveys made by different persons, using differing methods. That there had been retrocession within the period of our observation, he did not doubt; but it could scarcely be so rapid as was indicated by the estimates of Dr. Pohlman. Other speakers discussed the paper, which was of special interest, because it fired the first gun of the glacialists in the geological section, and it roused their opponents.

#### Glacial cañons.

BY W. J. MCGEE OF SALT LAKE CITY, UTAH.

THIS paper was read, in the absence of its author, by Mr. Warren Upham. It considered the action of a glacier as being, to a certain extent, capable of representation by mathematical formulæ. It was admitted, however, that some of the quantities in the equations must remain very indefinite. The paper was almost wholly theoretical, and arrived at the following conclusions: The temporary occupancy of a typical water-cut cañon by glacier-ice will, 1°. increase its width; 2°. change the V to a U cross profile; 3°. cut off the terminal portions of tributary cañons, and thus relatively elevate their embouchures; 4°. intensify certain irregularities of gradient in the cañon bottom; 5°. excavate rock basins; 6°. develop cirques; and, in general, transform each cañon into an equally typical glacial cañon. It follows that these features do not necessarily imply extensive glacial excavation, or indicate that glaciers are superlatively energetic engines of erosion.

Owing to the custom of abstaining from discussion on a paper in the absence of its author, the dissentient opinion of many who were present was not

fully elicited. The general expression was to the effect, that the theory had been framed without sufficient observation of the facts, and that, if the author had taken the trouble to see and examine various cañons, he would have come to a widely different set of conclusions.

**The ancient glaciation of North America: its extent, character, and teachings.**

BY J. S. NEWBERRY OF NEW YORK.

WHILE the glacial area on our continent has not been fully explored, there is abundant proof for the following propositions: 1°. Glaciers covered most of the elevated portions of the mountain belts in the far west as far south as the 36th parallel, and in the eastern half of the continent to the 40th parallel of latitude. 2°. The ancient glaciers, which occupied the area above described, were not produced by local causes, but were evidences of a general climatic condition. 3°. They could not have been the effect of a warm climate and an abundant precipitation of moisture, but were results of a general depression of temperature.

The traces of glaciation are similar in kind, and apparently in date, over the whole area: they are therefore effects of general, not of local, causes. East of the Mississippi, the evidence is even more widespread and impressive than in the far west. The area bearing marks of ice action, and strewn with drift, extends from New England westward, parallel with the Canadian highlands, in a belt five hundred miles wide and over two thousand miles long. Its northern extension has not been traced beyond Winnipeg; but there are reasons for believing that it reached to the Arctic ocean, and that the great lakes are pre-glacial river-valleys, scooped out and modified by ice. Fully half the continent north of the 36th parallel was glaciated. So far as we now know, the glaciation was synchronous.

The iceberg theory was opposed by Dr. Newberry, on the following grounds: It postulated a water-line with irregularities of level that are irreconcilable. The direction of the scratches, and the lines of deviation of the boulders, require that the northern portion of the continent should have been all submerged, leaving no land for the origin and starting-point of icebergs. If the icebergs could have been formed and floated, an incomprehensible tangle of ocean-currents would be required to account for their movements. The evidence of sea-covering, in the form of marine shells, is totally absent from the great drift area of the interior, while they are found abundantly in the Champlain and boulder clays of the coast. Finally, the inscription left by the eroding agency is characteristic and *sui generis*.

The record of the ice period on our continent is far more extensive and impressive than it has been represented. The phenomena were due to an extraneous and cosmical cause, not to any thing local or even telluric. The question here passes from the geologist, and must be addressed to the astronomer. Professor Newberry briefly recapitulated some of the

theories which have been suggested by Croll, Newcomb, and others, to account for the glacial epoch.

**Result of explorations of the glacial boundary between New Jersey and Illinois.**

BY G. F. WRIGHT OF OBERLIN, OHIO.

AFTER citing reasons for desiring a careful *résumé* of the subject, — the observations being scattered in the works of different explorers, — the author proceeded to name those who had determined, for different regions, the southern boundary of the glacial area. Starting at the eastern coast, President Edward Hitchcock was the first to intimate that the backbone of Cape Cod was a part of the terminal moraine if the theory of Professor Agassiz were true. Clarence King made a similar assertion as to accumulations near Wood's Holl and on the Elizabeth islands. Professor Charles H. Hitchcock declared that the backbone of Long Island was the foot of a terminal moraine. Warren Upham went over this field, from the end of Cape Cod to Brooklyn, to verify the hypothesis. Professors Cook and Smock traced the moraine across the state of New Jersey. Professor Lesley commissioned Professor Carvill Lewis and the author of the paper to continue the exploration across Pennsylvania. In Ohio, Professor Newberry has approximately outlined the boundary; but in Ohio, Indiana, and Illinois, the survey was carried on by a number of different persons before the most distinctive glacial features were fully understood.

The chief indications on which reliance can be placed to determine glacial action are striated rocks, striated stones, boulders, and till. Rocks near the margin are often so deeply embedded in till, that their markings are not apparent. The softer rocks do not always retain their striae: this has often been the case in Ohio. In certain situations, stones might be striated by a landslide, or the grounding of an iceberg; but the area over which striated stones are found is too vast for such explanation of their presence. The boulders are of granite and metamorphosed rocks from northern Canada and the shores of Lake Superior: their presence is relied upon only when they are on such high lines as to preclude the likelihood of their having been transported by the agency of rivers. Till is spread over the whole area: it is defined as an unstratified deposit, containing striated stones of various sizes, — fragments of rock foreign to the locality. Its composition varies, through mixture with underlying material. It covers and gives fertility to northern Ohio, Indiana, and Illinois. Till has been characterized by Professor Newberry as the grist of the glacier.

Briefly told, the boundary-line of the glaciated area, so far as now accurately known, is as follows: Beginning on the island of Nantucket, it runs through Martha's Vineyard, No Man's Land, Long Island from east to west, across Staten Island, entering New Jersey at North Amboy, and after bending northward and making a right angle near Dover, crosses the Delaware at Belvidere. Thence it runs north-westerly through Northampton, Monroe, Luzerne, Columbia, Lycom-

ing, Tioga, and Potter counties in Pennsylvania, and Cattaraugus county, New York, reaching its most northerly part about five miles north of Salamanca. From here it runs through Warren, Venango, Butler, Lawrence, and Beaver counties, to the Ohio line, crossing Beaver creek at Chaintown about fifteen miles above the Ohio river.

The boundary enters Ohio in the northern part of Columbiana county, and proceeds nearly west to the middle of Stark; then turns more to the south, touching the corner of Tuscarawas, and dividing Holmes into two nearly north-and-south sections. Near the north-east corner of Knox, the line makes a right angle, and runs south through Knox, Licking, the north-west corner of Perry, Fairfield, Ross, Highland, Adams, and Brown counties. Then it follows the line of the Ohio river across Clermont, and enters Kentucky near the boundary between Pendleton and Campbell counties, and, after crossing the northern part of Kenton and Boone counties, recrosses the Ohio, entering Indiana a little below Aurora.

In Indiana the line still continues to bear in a southerly direction through Ohio and Jefferson counties, grazing the edge of Kentucky again opposite Madison, and reaching its southernmost point near Charleston in Clarke county, Ind. From here it bears again to the north, through Scott and Jackson counties, to the line between Bartholomew and Brown, and follows this to the north-east corner of Brown. There again it turns to the south-west, touching the north-east corner of Monroe, where it again bears north for ten miles, to near Martinsville in Morgan county. Here again the line turns west and south, passing diagonally through Owen and Green counties, and in Knox as far as Harrison township, ten miles south-east of Vincennes. Beyond this point, the author did not propose at present to trace the line.

The signs of glaciation cease where there is no barrier to account for their cessation, and where no barrier ever could have existed such as must be supposed if the so-called glacial phenomena are the product of floating ice. Of the correctness of this inference, the different elevations at which the signs of glacial action cease are sufficient proof. For instance, the line is near sea-level in New Jersey; in Pennsylvania it rises over Mount Kittatinny to a height of 1,200 feet, then descends 800 feet into a valley, and, again rising, reaches the summits of mountains 2,000 feet above sea-level. Crossing the valley of the Susquehanna at an elevation of only 500 feet, the line mounts the Alleghanies diagonally, and runs over them at a height of 2,500 feet.

The paper proceeds to describe certain marked features of glaciated areas. South of New England, the terminal line is characterized by a series of glacial hills, 100 to 300 feet high. These are also observable in New Jersey, near Plainfield and Menlo Park.

Among the most interesting results of the author's survey in Ohio, was the demonstration of the existence of an ice-dam across the river at Cincinnati. The line bounding two glacial accumulations crosses

the Ohio river into Kentucky, near the boundary between Campbell and Pendleton counties, about twenty-five miles above Cincinnati, and recrosses it near Aurora, Ind., about twenty-five miles below Cincinnati, thus filling the channel for about fifty miles of its course. The Ohio, it should be said, occupies, throughout nearly its whole extent, a narrow valley of erosion, not often more than a mile wide, and from 300 to 500 feet deep. Emptying into the main channel there are subordinate channels all along, of smaller dimensions, but of nearly equal depth. The proofs that the ice bodily crossed the river at the point indicated are, that till and granitic boulders are found in the Kentucky hills south of the river to a certain distance, and not beyond it.

To the question, Why is the boundary of the glacial area so crooked? the author replied at some length; assigning as a principal cause, aside from differences of level, the probability that unequal amounts of snow fell over different regions of the north. The effect of such differences of accumulating snowfall, in determining the extension of the glacial outline, is illustrated by supposing that two loads of sand are placed in one pile, and one load in an adjoining pile; when the sand will flow downward to unequal distances upon a level.

A little reflection will show that the glacial theory will not make extravagant suppositions as to the amount of ice required. The ice was indeed 600 feet deep over New England, and, very likely, of an equal depth over the area to the west; but it is not necessary to suppose a great increase of this depth to the north. All that is necessary is to suppose great accumulations of ice to the north of the granitic hills of Canada, starting a movement past them to the south. This movement may have been kept up toward the margin by fresh accumulations of snow upon the spreading glacier. An accumulation of snow over the glacier in any part of it would spend its effective force in giving impetus to the movement of the front along the lines of least resistance.

The discussion which followed the reading of this paper took a wide range, as the paper itself contained many points of interest. The opponents of the glacial theory, or of the younger theories which have sprung from its loins, based their criticisms chiefly upon doubts of the evidences of glaciation. The questions raised, as to the distinctive characteristics of glacial and subaqueous deposits, gave tone to the paper of the next speaker, which was delivered orally, and was, at least in part, extemporaneous.

#### The terminal moraine west of Ohio.

BY T. C. CHAMBERLIN OF BELOIT, WIS.

THIS paper was introduced by a statement of the author's views on some points that had been alluded to in the discussion of Professor Wright's paper. Dr. Chamberlin had himself observed the features of the drift-bearing area west of the Rocky Mountains. Certain of the drift clays are unquestionably glacial: others have quite as certainly had a wholly different origin. He specified with great particularity the

means for discrimination between the clays, but admitted that there were instances where the different types seem to blend insensibly into each other.

West of the Scioto valley, the border of the drift-bearing area is not marked by what is regarded as a moraine. There is, however, an extension of what Professor Wright has characterized as the 'glacial fringe,' consisting of bowlders. In Dakota county, Minn., this fringe is very wide. At Crystal lake there is a well-marked moraine, and possibly there is another a little to the westward. Farther to the west, there is no accumulated morainic drift. West of the Missouri, there is no evidence of glacial ploughing.

A line of drift-hills known as the Potash Kettle range, in eastern Wisconsin, had been regarded as an old beach-line. Dr. Chamberlin has ascertained that the range is a glacial moraine. He described it as an interlobate moraine, formed jointly by glacial lobes occupying the valleys of Lake Michigan and Green Bay, respectively. This was correlated with moraines to the westward in Wisconsin.

Furthermore, there was a system of moraines, — a belt or group, including the glacier lobes at Lake Michigan, in the Chippewa valley, at the western extension of Lake Superior, and in the valley of the Minnesota River, and Red River of the North. These moraines were more pronounced, with a few exceptions, than those on the outer edge. Investigations were being carried eastward with a view of showing their correlation with other moraines in that direction. The hypothesis of their exact correlation, of course, would imply that they were contemporaneous; but there are doubts upon that point.

The author claimed, that there were evidences that the lake-basins were caused in part by depressions during the ice age, caused by the exceptional accumulation of ice in the basins. He deprecated the notion that subsidence must always take as long a period as elevation, or that the reverse is true. He applied this to the case which he alleged of the depression during the presence of ice in the lake-basins, and the elevation since.

In discussing this paper, Professor Lesley said it was time to cry halt as to this theory of depression by weight of ice. It was made to do duty for a great variety of emergencies. In point of fact, ice was much lighter, very much lighter, than any rock. Professor Lesley pointed out instances where this theory had been advanced to account for depressions which now contained a greater weight than the ice could have made with any reasonable hypothesis of its thickness.

Professor Chamberlin explained the theory further, and claimed that in instances which he cited the depression was greatest at the weakest part of the strata.

Prof. E. S. Morse referred to some English experiments to determine the question whether the moon's attraction deformed the earth's outline. It was found (according to newspaper report), that the weight of the incoming tide deformed the surface to such an extent that the effect of the moon's attrac-

tion could not be separately calculated. Major Powell called attention to the theory, that, if the earth were divided into conical sections radiating from its centre, there would be found an equal pressure in each. Every sediment, every erosion of the surface, must be balanced by corresponding depression or rise elsewhere. Finally, the case of Lake Saltonstall was cited by Mr. Hovey. It is evidently situated in a valley that was ploughed out by the foot of a glacier; certainly not in a hollow caused by pressure. Professor Cox clung to another theory entirely, as to the great lakes. He believed them to be prolongations of a sea-coast which had at one time extended to them through the valley of the St. Lawrence.

### The Minnesota valley in the ice age.

BY WARREN UPHAM OF MINNEAPOLIS, MINN.

THE paper was based upon the author's observations for three years as assistant on the geological and natural-history survey of Minnesota, under the direction of Professor Winchell. To the question: During what ages was the glacial, rock-walled channel of the valley of the Minnesota River formed? — the paper offered an answer. Deposits of cretaceous clay were found in water-worn hollows at several enumerated localities; and, in other places, cretaceous sandstone and shale occasionally containing lignite. It thus appears, that, before the cretaceous age, a deep channel had been cut by some river in the lower magnesian sandstone, and the Potsdam formation. The slopes, the drainage, perhaps even the channel, of that river, were not widely different from those of the present; but that channel was probably eroded during the later paleozoic and earlier mesozoic ages, before the cretaceous subsidence.

In the first epoch of glaciation, when the ice covered its greatest area, a thick drift-sheet, mostly unmodified, probably covered all this region, including the preglacial valley, with an unbroken, though undulating, expanse of till. During the ensuing interglacial epoch, the drainage cut a channel, whose position was largely determined by the slopes of the erosion which had preceded the glacial epoch. The preglacial, and also the interglacial river, lay far below the present stream. The till of the later epoch blocked the course of the river only in part of its extent, and the obstacle was soon channelled anew.

During the recession of the last ice-sheet, the valley was filled with modified drift. After the ice was melted in the Minnesota basin, this avenue of drainage was, for a long period, the outlet of Lake Agassiz. The volume of water that it carried was very large, being supplied by the melting ice-fields of Northwestern Minnesota, and from the region of Lake Winnipeg and the Saskatchewan. While streams poured into this river from the melting ice-sheet, its modified drift continually increased in depth; but, when the great glacier had sufficiently retreated, the water from Lake Agassiz not only ceased to contain drift, but became a powerful eroding agent. The deposited drift was mostly swept away, and the channel

was again excavated, perhaps to a greater depth than the present river, possibly to the bottom of the gravel and sand, at a point in the valley which is 150 feet below the river there, and 135 feet below low water in the Mississippi at St. Paul.

When the ice-barrier which had made Lake Agassiz disappeared, that lake was drained northward toward Hudson bay. Thenceforward, the rivers of the Minnesota and Mississippi valleys carried only a fraction of the former volume of water from this source. They have since become extensively filled with alluvial gravel, sand, clay, and silt, brought in by the tributaries of those rivers. The changes produced by this post-glacial sedimentation have been ably discussed by Gen. G. K. Warren, and were briefly summarized in the paper of Mr. Upham.

Lake Superior seems to have been held by an ice-barrier at a level of about 500 feet from its present height. The locality of its overflow was stated, and various results detailed. Lake Michigan, until the ice-sheet receded from its northern border, discharged southward by the Illinois river, which, like the former outlet of Lake Superior, was eventually obstructed by alluvium, so that now it has a very slight current for two hundred miles.

The paper closed with a proposition to call the ancient river of the glacial age, the river Warren, in honor of Gen. G. K. Warren.

The discussion which followed was, in part, a conflict between the glacialists and their opponents, and, in part, a debate upon the general question of naming geological features after distinguished investigators.

#### Changes in the currents of the ice of the last glacial epoch in eastern Minnesota.

BY WARREN UPHAM OF MINNEAPOLIS, MINN.

WITHOUT a map, or a thorough familiarity with the region referred to, this paper would not convey very definite ideas. Through some inadvertency the map intended to be used was not on hand when the paper was read. The author's observations had led him to conclusions of a very definite character. He conceived, that, when the ice of the last glacial epoch attained its maximum extent, there were two ice-currents. One moved south-westerly from Lake Superior, across the north-east part of Minnesota, spreading a reddish till with bowlders and pebbles, and limited by a line from Lake St. Croix south-west across the Mississippi, and thence bending north-west by Lake Minnetonka, and through Wright and Stearns counties. The other portion of the ice-sheet was pushed from the region of Lake Winnipeg, south and south-east. The two met along a line from Stearns county, south-east by Lake Minnetonka to Crystal Lake, Dakota county. Afterward, when the ice had partly melted and retreated, a second and inner terminal moraine was formed. Owing to climatic changes (the rationale of which was carefully and very explicitly set forth in the paper), the current from the north-west pushed back that from the east, and covered the reddish till, already deposited, with a

blue till from the west and north-west, also abundant in its peculiar bowlders and other evidences of its source.

#### The kame rivers of Maine.

BY G. H. STONE OF COLORADO SPRINGS, COL.

IN the absence of its author, this paper was read by Mr. Upham. After defining and describing the characteristics of kames, and stating that they are very numerous in Maine, where he had observed them, the author proceeded to discuss a single question in relation to these geological features. Most glacialists are agreed that the kame gravels of the drift region were chiefly deposited by glacial streams. The question is, whether these streams were sub-glacial or super-glacial. In exploration during the past five years, the author had found evidences of both kinds of streams; but he nowhere found stratified or even water-classified material enclosed in this formation, except within a few miles of the coast.

The essayist sought to answer the question by considering the processes of melting which take place in a glacier. Strict analogy with existing glaciers—even with those of Greenland—should not be supposed. In modern glaciers, nearly all the water of their lower extremities is sub-glacial. The ice is so broken by crevasses that melting waters soon find their way to the bottom. But a different state of affairs may have prevailed in the continental glacier. Several of these kame rivers are a hundred or more miles in length. Granting all reasonable development of sub-glacial streams, these kames can scarcely be thus accounted for. Superficial water flowing along the surface would gradually deepen its channel: when the melting had so far proceeded that the bottoms of these streams reached the moraine stuff in the lower part of the ice, the kame gravel would begin to gather on the bottoms of their channels. During the final melting, when the condition was such that few if any additional crevasses would be formed, there would be no time to extend the previously formed sub-glacial channels. The sudden floods would pass over the lowest part of the ice as they would over ground. A great and rapid northward extension of the superficial streams would result.

In discussing this paper, Mr. Upham stated that erosion does not appear in kames. They are not unfrequently a hundred feet in height: one on the borders of the Merrimac river was instanced. They appear to be gravel deposits laid down before the glacier was fully melted.

#### Relation of the glacial dam at Cincinnati to the terrace in the upper Ohio and its tributaries.

BY I. C. WHITE OF MORGANTOWN, W. VA.

THIS paper, in the absence of its author, was read by Professor Winchell.

In a paper read before the Boston society of natural history, March 7, 1883, Rev. G. F. Wright showed that the southern rim of the great northern ice-sheet

covered the Ohio river near the site of New Richmond, a few miles above Cincinnati; and presented the hypothesis, that one effect of this invasion of the Ohio valley by the glacial ice was to form an immense dam of ice and morainic *débris*, which effectually closed the old channel way, and set back the water of the Ohio and its tributaries, until, rising to the level of the Licking River divide, it probably found an outlet through Kentucky, around the glacial dam. The writer of the essay, after reviewing the evidence, regards Mr. Wright's hypothesis as proved beyond a reasonable doubt. He also claimed, that during the period of the continuance of the dam, the principal tributaries of the Ohio had their valleys filled with sediment carried down and dumped into them by the mountain torrents and other streams which drained the area south from the glaciated region; that subsequently, when the barrier disappeared, the rivers recut their channels through the silt deposits, probably by spasmodic lowering of the dam, in such a manner as to leave the deposits in a series of more or less regular terraces, which in favored localities subsequent erosion has failed to obliterate, though from steep slopes it has removed their every trace. The elevation of this dam at Cincinnati, as determined from the upper limit of the fifth Monongahela River terrace, would be somewhere about 625 feet above low water there in the present Ohio.

In discussing this paper, Professor Lesley said that there were two separate glacial formations to be considered, and the two could not be correlated. The ice-dam could not thus be explained. Professor Wright had discussed the subject with clearness, claiming that the dam was glacial; but at best there were only a few places in the west where the height of the ice could be measured.

### The eroding power of ice.

BY J. S. NEWBERRY OF NEW YORK.

THE object of this essay was to enter a protest against the theories of certain geologists who claim that glacial ice has not played an important part in the erosion of valleys. They have undertaken to deny that ice has any great excavating power. Examples of utterances of this school, the speaker said, were to be found in Prof. J. D. Whitney's Climatic changes; in papers by Prof. J. W. Spencer, on the Old outlet of Lake Erie; by Mr. W. M. Davis, on the Classification of lake basins, and the erosive action of ice; and remarks on the same subject by Prof. J. P. Lesley.

The most important heresies which had been advanced in regard to this subject were, first, the denial that there was ever a glacial period; second, if there was an ice period, it was a warm and not a cold one; third, that the phenomena usually ascribed to glacial action in the record of an ice period were generally due to icebergs; fourth, that ice has little or no eroding power, and that glaciers have never been an important geological agent. Professor Newberry pro-

ceeded, in controversion of these theories, to give the results of his extended studies of geological action in the Alps and in many different regions of the United States and Canada. These observations lead to the conclusions, 1°. That the glacial period was a reality, and that its record constitutes one of the most important and interesting chapters of geological history; 2°. That this was a cold period; 3°. That ice has a great, though unmeasured and perhaps immeasurable, eroding power; and that, in regions which they have occupied, glaciers have been always important, and often preponderating, agents in effecting geological changes.

No cautious geologist would assert or concede that all lake-basins had been excavated by ice, but to deny its influence in their formation would be a far greater error. The basins of our great lakes, and of many of our smaller ones, bear the traces of ice that has moved in the line, at least approximately, of their major axes. The broad, boat-shaped basins indicate the work of this same agency. The islands of Lake Erie are carved from the solid rock: their surfaces and sides, and the channels between them, are all glaciated. The plastic ice has inwrapped those islands, fitting into every irregularity, and carving, with the sand it carried, every surface. The marks of glaciation are to be seen on mountain belts from Canada to Mexico. Even at the present day glaciers are transporting enormous loads. In midsummer the Aar glacier brings down 280 tons per day; the Justedal glacier of Norway wears down, it is estimated, 69,000 cubic meters of solid rock annually. These measurements of the eroding power of two small glaciers should show the fallacy of a denial of the excavating power of ice. Dr. Newberry concluded by citing authorities on the subject.

This paper elicited the most acrimonious discussion of the meeting. Professor Lesley took exception to certain phrases in the paper which seemed to cast a reflection upon the methods of his coadjutors, — men who were conscientiously engaged in scientific investigation, and had seen reason for breaking away from the trammels of opinion formulated by Agassiz and Ramsey. For himself, he did not believe in the theory of erosive glacial processes, and he asserted that there was no good reason for believing that the basins of the great lakes were so produced. He claimed that the basin of Ontario was a Silurian valley; the basins of Erie, Michigan, and Huron, were Devonian valleys. Ice had no more eroding effect than a piece of sandpaper has upon a rough board. He believed in the eroding of water, and represented his idea of the relative power of ice and water, as follows: Ice, 1; rain-water, 10; acidulated water, 100; ice set with stones, 1,000; water set with stones, 10,000.

Professor Newberry disclaimed any intention of attacking the young men of science who were laboring in this field. He re-affirmed the positions taken in his paper. On the other hand, Professor T. Sterry Hunt declared his substantial agreement with the views of Professor Lesley. On account of the length of this debate, the five-minute rule for discussions was adopted and subsequently enforced.

**Informal remarks on moraines and terraces.**

BY J. W. DAWSON OF MONTREAL, AND J. W. POWELL OF WASHINGTON.

At the opening of the morning and afternoon sessions of the geological section in its last day's work, Dr. Dawson and Major Powell made respectively some informal remarks of interest. Dr. Dawson objected to the loose significance with which the term 'moraine' had been used, and especially to the definition of it as 'detrital matter heaped up by the forcible mechanical action of ice.' He pointed out that such a definition would include work which certainly was not performed by land glaciers.

Dr. Dawson described the glacial deposits exposed along the line of the Canadian Pacific railway, from the Laurentian areas west and north of Lake Superior to the Rocky Mountains, noticing the lacustrine deposit of the Red-river valley, containing only a very few, small, ice-borne stones; the second prairie level covered with Laurentian drift from the north-east, and with an interrupted ridge of scrub material extending along the middle of it, northward from Turtle mountain. He referred to the great Missouri coteau, at an elevation of 2,500 feet, and made up of local mud, and sand, with Laurentian boulders piled up against the higher prairie steppe; the drift on the surface of this steppe being partly Laurentian and Silurian from the east, and partly from the Rocky Mountains. He finally stated, that huge Laurentian and Huronian boulders were placed at an elevation of more than 4,000 feet on the foot-hills of the Rocky Mountains, more than 700 miles from their original site. He did not intend to offer any explanation, as investigations into the matter were still being carried on by his son; but he wished to say briefly, that it appeared to him perfectly plain that we could not account for such phenomena as had been described, without taking into account great changes of level, or, without doubt, great submergence and reemergence.

Major Powell called attention to the fact, that wholly different agencies, each acting in its own way, produced a class of geological features that went under the general name of 'terraces.' We have sea-beach terraces, lake-shore terraces, and yet another class of terraces exceedingly common in the Rocky and the Cascade mountains. The last-named class of terraces is due to a different cause from the others. Some of this class in the east have been relegated erroneously to the class of beach terraces: those which are said to dam the Ohio, and others found in the Alleghanies, have been formed by a process which can be briefly sketched.

We have a valley. It runs irregularly between bluffs and mountains. We have a force in the river which simply tends down stream; it is itself irregular, its energy depending upon its transient volume and local depth. If the region is upheaved, the river no longer keeps its old course. It seeks the line of least resistance, and may form a new flood-plain below. Then the river, for a while at least, excavates laterally instead of vertically. No

longer occupying its old place in the valley, it gradually cuts a new path. But the old terrace may remain. In some places there are more than twenty systems of terraces: in a locality near Pittsburgh, there are fifty-three such systems. These the speaker regarded as chiefly due to changes in the level of the regions,—to elevations and depressions. Further explanation by the speaker was cut short under the five-minute rule.

**(OTHER GEOLOGICAL PAPERS.)**

**The earth's orographic framework; its seismology and geology.**

**The 'continental type,' or the normal orography and geology of continents.**

BY RICHARD OWEN OF NEW HARMONY, IND.

THESE papers were read successively, as being closely related. They refer to a well-known theory of their author, which traces the frame-work of the earth in its mountain chains. He finds such a frame-work running from east to west in numerous parallel ranges near the equator, and instances those of Sumatra and of South America. This he calls the 'strong girdle' of the earth: it is of mesozoic age, terminating its heights in the cenozoic age. Remotely parallel are the arctic and antarctic belts. Great braces come down to meet this girdle, having at least four ramifications in Asia, starting from the great plateau, and in America forming the great 'backbone' of the continent. The five equidistant continental trends of mountain chains often mark paleozoic belts. But the later as well as the older results tell of strong interior forces that have produced the mountains, and the central belt gives marked evidence that an intense reaction from within aided in its construction.

The similarity of the five great continents has often been the occasion of remark. They seem to have a general plan of construction, that may have been connected with their appearance as land above the ocean. The similarity extends even to their present geographical area. If we cut cross-sections from W. S. W. to E. S. E. through the geographical centre of each continent, we shall find in each case a seismic belt near one rim of the continent, and often near both rims. Thus the continent is usually basin-shaped, and comparatively low in its central area with its chief river drainage, and low near the ocean borders; rising in an eastern and western main range, with usually several parallel subordinate ridges. These eastern and western mountains converge southerly, thus assuming a somewhat irregular form, evolving usually on the west some table-land. The eastern river is usually paleozoic, with perhaps some mesozoic on the flanks and cenozoic on the ocean border. The western elevation is more commonly mesozoic in its main range, and cenozoic in the flanks or subordinate ridges. A section running north and south through the three northern continents would successively expose Cambrian, paleozoic, mesozoic, and cenozoic cuts, which would generally increase in area as we go south.

The papers of Professor Owen elicited, for the greater part, unfavorable comment. It was urged against them, that their generalizations were too broad, and that they were based rather upon closet study than actual observation. As to at least one of the continents, we know as yet far too little of its geology, especially in the interior, to frame a theory of its history and constitution.

### The pre-Cambrian rocks of the Alps.

BY T. STERRY HUNT OF MONTREAL, CAN.

THE writer began by reviewing the history of Alpine geology, and noticed first that speculative period when the crystalline rocks of the Alps, including gneisses, hornblendic and micaceous schists, euphotides, serpentines, etc., were looked upon as altered sedimentary strata of carboniferous or more recent times. He then traced the steps by which these views have been discarded, and more and more of these rocks shown to belong to eozoic or pre-Cambrian ages. In this connection the labors of von Hauer, Gerlach, Heim, Favre, Renevier, Lory, Gastaldi, and others, were analyzed; and reference was made to the great progress since the writer in 1872 published a review of Favre on the geology of the Alps.

The sections by Neri, Gerlach, and Gastaldi in the western, and those of von Hauer in the eastern Alps, were described; and it was shown that all these agree in establishing in the crystalline rocks four great divisions in ascending order: 1°. The older granitoid gneiss with crystalline limestones, graphite, etc., referred by Gastaldi to the Laurentian. 2°. The so-called *pietre verdi*, or greenstone group, consisting chiefly of dioritic, chloritic, steatitic, and epidiotic rocks, with euphotides and serpentines, including also talcose gneisses, limestones, and dolomites, and regarded by Gastaldi as Huronian. 3°. The so-called recent gneisses of von Hauer and Gastaldi, interstratified with and passing into granulites and micaceous and hornblendic schists, also with serpentines and crystalline limestones. 4°. The series of argillites and soft glossy schists with quartzites and detrital sandstones, including also beds of serpentine with talc, gypsum, karstenite, dolomite, and much crystalline limestone. This fourth series, well seen at the Mont Cenis tunnel, is still claimed by Lory and some others as altered trias; but the present writer's view, put forth in 1872, that it is, like the preceding groups, of eozoic age, was subsequently accepted by Favre and by Gastaldi, and is now established by many observations. To this horizon belong the crystalline limestones of the Apennine Alps, including the marbles of Carrara.

The writer next recalls the fact that he, in 1870, insisted upon the existence of a younger series of gneisses in North America, alike in the Atlantic states, in Ontario, and to the north-west of Lake Superior. These, in his address before the American association for the advancement of science, in 1871, he further described under the name of the White-Mountain series, and subsequently, in the

same year, called them Montalban. These rocks were then declared to be younger than the Huronian, and to overlie it; though, in the absence of this latter, it was pointed out that in Ontario and in Newfoundland the Montalban reposes unconformably upon the Laurentian. When these newer gneisses and mica-schists were first described, in 1870, there was included with them an overlying group of argillites, quartzites, and crystalline limestones; and for the whole the name of Terranovan was suggested, provisionally. But in defining, in the following year, the White-Mountain series, this upper group was omitted, and was subsequently referred to the Taconian series, — the lower Taconic of Emmons, and the so-called altered primal and auroral of H. D. Rogers, in eastern Pennsylvania.

The writer next describes his own observations in the Alps and the Apennines in 1881. He affirms the correctness of Gastaldi in referring the groups one and two to Laurentian and Huronian, finds the third, or the younger gneiss and mica-schist group of the Alps, indistinguishable from the Montalban, and regards the fourth as the representative of the American Taconian. It was maintained by Gastaldi, that these pre-Cambrian groups of the Alps underlie directly the newer rocks of northern and central Italy, forming the skeleton of the Apennines, reappearing in Calabria, and, moreover, protruding in various localities in Liguria, Tuscany, and elsewhere. The serpentines, euphotides, and other resisting rocks thus exposed, have been regarded as eruptive masses of triassic and eocene time. The writer, however, holds with Gastaldi, that they are indigenous rocks of pre-Cambrian age, exposed by geological accidents.

The uncrystalline rocks of the mainland of Italy are chiefly cenozoic or mesozoic, and the only paleozoic strata known are carboniferous, the organic forms in the limestone of Chaberton having been shown to be triassic. Triassic, liassic, cretaceous, eocene, and miocene strata are found in different localities, resting on the various pre-Cambrian groups. In the island of Sardinia, however, all these are overlaid by a great body of uncrystalline lower paleozoic rocks, in which the late studies of Bornemann and Meneghini have made known the existence of a lower Cambrian fauna, including *Paradoxides*, *Conocephalites*, and *Archeocyathus*, succeeded by an abundant fauna of upper Cambrian or Ordovician age.

The existence of the younger or Montalban gneiss in Sweden and in the Harz and the Erzgebirge was noticed, and to it were referred the Hercynian gneisses and mica-schists of Gumbel. The presence both in Sweden and in Saxony of conglomerates, as described by Hummel and by Sauer, wherein pebbles of the older gneiss are enclosed in beds of the younger series, was discussed, and the direct unconformable superposition of the latter upon the older gneiss, in the absence of the Huronian, was considered; evidences of the same relations being adduced from the Alps. The gneisses of the St. Gothard, as seen on the Italian slope, were also referred to the newer series; and the important studies of Stapff in this

connection were discussed. It was declared that the views put forth by the author in 1870-71, on the relations and succession of the crystalline stratified rocks in North America, and then extended by him to Europe, have been fully confirmed by the labors of a great many European geologists, as already shown. Those of Hicks, Hughes, Bonney, Callaway, Lapworth, and others, in the pre-Cambrian rocks of the British islands, were cited in support of these conclusions. It was said, that, whatever may have been the conditions under which these vast series of crystalline stratified rocks were deposited, there is evidence, in the similarity of their mineralogical and geognostical relations, of a remarkable uniformity over widely separated regions of the earth's surface, as well as of long intervals of time, marked by great foldings and disturbance, and by vast and wide-spread erosion of the successive series of rocks.

In conclusion, the writer took occasion to call attention to the important labors of the present school of Italian geologists, and their great zeal, skill, and disinterested service, as shown in the memoirs of the R. accademia dei lincei, and in the work of the Royal geological commission, including the special studies, maps, and memoirs prepared by it for the International geological congress of Bologna in 1881. The new Geological society of Italy, founded at the same date, gives promise of a brilliant future, and has already published many important memoirs.

### The serpentine of Staten Island, New York.

BY T. STERRY HUNT OF MONTREAL, CAN.

THE serpentine of Staten Island appears as a north-and-south range of bold hills rising out of a plain of mesozoic rocks, which on the west side are triassic sandstones like those of the adjacent mainland, including a belt of intrusive diorite, and on the east the overlying, nearly horizontal, cretaceous marls, which are traced south and west into New Jersey. The only rocks besides these mentioned, seen on the island, are small areas of a coarse-grained granite, having the character of a veinstone or endogenous mass, and others of an actinolite rock; both exposed among the sands on the north-east shore of the island.

Mather, who described this locality more than forty years since, looked upon the serpentine as an eruptive rock, related in origin to the parallel belt of diabase which is included in the triassic sandstone to the west. Dr. Britton, of the School of mines, Columbia college, who in 1880 published, in the transactions of the New-York academy of sciences, a careful geological description and map of the island, regarded the serpentine belt as a protruding portion of the eozoic series, including serpentine, which is seen at Hoboken, on Manhattan Island, and in Westchester County, New York, — a conclusion which the writer regards as unquestionably correct.

The appearance of isolated hills and ridges of serpentine is common in other regions, and is by the writer explained by the consideration that this very insoluble magnesian silicate resists the atmospheric agencies which dissolve limestones, and convert

gneisses to clay; the removal of which rocks leaves exposed the included beds and lenticular masses of serpentine. Similar appearances are seen in many parts of Italy, where ridges and bosses of serpentine are found protruding in the midst of eocene strata, and have hitherto by most European geologists been regarded as eruptive masses of tertiary age. The problem is there often complicated by the fact that subsequent movements of the earth's crust have involved alike the older crystalline strata (of which the serpentines form an integral part) and the unconformably overlying eocene beds; faulting and folding the latter, and even giving rise to inversions by which the newer rocks, overturned, are made to dip towards and beneath the ancient crystalline masses. This the writer illustrated by reference to localities recently examined by him in Liguria and in Tuscany, where this relation of the serpentines had already been pointed out by Gastaldi. The structure in question was declared to be analogous to that presented by similar foldings and overturns to be seen along the western base of the Atlantic belt throughout the Appalachian valley.

The speaker further alluded to the fact, that, although the sub-aërial decay of serpentine was far less rapid than that of most other rocks, it had not escaped this process; and described the decayed layer on portions of the Staten Island serpentine hills, including a chromiferous limonite segregated from the decayed serpentine. This was a slow pre-glacial process, and in the subsequent erosion of the serpentine ridges the decayed layer has been in parts entirely removed. The details of this decay, and its relations to the limonite, and to glaciation in this locality, have been described by the writer in an essay on the decay of rocks, to appear in the *American journal of science* for September, 1883. He gratefully acknowledged his personal obligations to Dr. Britton for the many facts contained in his memoir and map, as well as for personal guidance during a late visit to Staten Island.

### The equivalent of the New-York water-lime group developed in Iowa.

BY A. S. TIFFANY OF DAVENPORT, IO.

THE author stated, that the upper Silurian rocks of Iowa had hitherto been classed wholly as of the Niagara limestone. There has, however, been some dispute as to the magnesian buff-colored limestone of the Le Claire and Anamosa quarries. Such disputes must, of course, be settled by the fossils; but he had been for more than twelve years seeking organic remains in that formation, without success until February of last year, when he found them in considerable quantities. Specimens of the fossils were exhibited. Mr. Tiffany considered that they gave conclusive evidence of belonging to a group higher in the scale than the fossils of the Niagara limestone, that their affinities were with those of the water-lime group of the lower Helderberg, and that the identity of many species had been determined.

### Clay pebbles from Princetown, Minn.

BY N. H. WINCHELL OF MINNEAPOLIS, MINN.

THIS paper was accompanied by an exhibition of specimens. The pebbles were of various shapes and sizes, several of them somewhat cylindrical. Outside, they are composed of fine sand and gravel; inside, they consist wholly of a fine sedimentary clay, such as is deposited by standing water, and contain no interior pebbles. Professor Winchell had compared these with pebbles found in till-deposits, and with various others, without finding any thing exactly similar.

Professor Newberry examined the pebbles, and admitted that they were not exactly like any that he had seen, but he thought they bore a general resemblance to pebbles found throughout the range of geological strata wherever there is a bed of sandstone capped by clay. Professor Claypole claimed to have seen similar specimens in Pennsylvania deposits.

### The 'earthquake' at New Madrid, Mo., in 1811, probably not an earthquake.

BY JAMES MACFARLANE OF TOWANDA, PENN.

AFTER dwelling upon the fact, that the locality of the alleged earthquake was not the seat of any apparent volcanic action, the author proceeded to state his view that the event in question was due to a different cause. He claimed that the locality was underlaid by cavernous limestones of the St. Louis group. He believed that what took place was a subsidence, due to the solution of underlying strata. He alluded to the descriptions afforded by Humboldt and Lyell, the latter having visited the locality, and given it a careful examination. The inhabitants described it as a convulsion, taking place at intervals during several months, creating new lakes and islands, changing the face of the country. The graveyard was precipitated into the Mississippi river; forest-trees were tilted in all directions; vast volumes of sand and water were discharged on high.

The author claimed that the long continuance of such phenomena, which lasted for several months, was an evidence that they proceeded from mere subsidence, and not from earthquake shock. In respect to the geology of the region, he stated that New Madrid and its vicinity rested on tertiary or quaternary strata. Underlying sub-carboniferous formations are represented near the borders of the depression. The sinking of a shaft brought to light coal, or coal-shales; also there were coaly shales found in the crevices and sink-holes thirty-five years after the so-called earthquake.

This paper elicited strong expressions of dissent from several members. Professor Cox declared that there were no sub-carboniferous rocks in that locality, no caverns, no soluble limestones underlying the surface. The shocks were sudden. There was great destruction of life. No mere subsidence can account for what actually happened. A question as to the truthfulness of the reports from that region brought out very contradictory opinions in the discussion.

Professor Cox, who had personally examined the scene of the occurrences, declared that he had found evidences of great disturbance. Professor Nipher suggested that the position of the trees, whether upright or not, which were alleged to be at the bottom of Reelfoot Lake (a lake formed at the time of the earthquake), would help to determine whether a subsidence, or an earthquake, had taken place. Some doubt was expressed as to whether any submerged trees were there. To these doubts and queries, Professor Cox was able to give a definite answer: he had seen the trees still upright beneath the water.

### Comparative strength of Minnesota and New-England granites.

BY N. H. WINCHELL OF MINNEAPOLIS, MINN.

HAVING had recent occasion to test the qualities of the building-stones of Minnesota, the author subjected them to the usual tests of crushing, using for this purpose specimens of two-inch cube. The specimens included sandstones, limestones, granites, and trap-rocks, and numbered about 100. Great care was taken in preparing them accurately. They were sent to Gen. Gillmore at Staten Island, and there subjected to the tests, which were applied by crushing the samples, one in the direction of the schistose structure and one across it. The following were the results with twenty samples of Minnesota granites:

Kind of stone.	Location of quarry.	Position.	Strength in pounds.	
			Of sample.	Per cubic inch.
Dark trap-rock, massive melaphyr . . .	(Taylor's Falls, Chisago county . . .)	On bed .	105,000	26,250
		On edge,	105,000	26,250
Dark trap-rock, from a dyke .	(Fischer's creek, n'r Duluth, St. Louis county, . . .)	On bed .	105,000	26,250
		On edge,	105,000	26,250
Gray gabbro, massive, fine,	(Rice's Point, Duluth, St. Louis county, . . .)	On bed .	109,000	27,250
		On edge,	105,000	26,250
Red, fine sienite . . .	(Beaver Bay, Lake county, . . .)	On bed .	106,000	25,000
		On edge,	103,000	25,750
Red quartzose sienite . . .	(Watab, Benton county . . .)	On bed .	103,000	25,750
		On edge,	103,000 <sup>1</sup>	25,750
Red quartzose sienite . . .	(East St. Cloud, Sherburne county . . .)	On bed .	112,000	28,000
		On edge,	105,000	26,250
Red quartzite .	(Pipestone City, Pipestone county . . .)	On bed .	111,000	27,750
		On edge,	108,000	27,000
Massive gray quartzose sienite . . .	(East St. Cloud, Sherburne county . . .)	On bed .	105,000	26,250
		On edge,	103,000	25,750
Fine - grained gray sienite .	(East St. Cloud, Sherburne county . . .)	On bed .	112,000	28,000
		On edge,	105,000	26,250
Fine - grained gray sienite, <sup>2</sup>	(Sauk Rapids . . .)	On bed .	86,000	21,500
		On edge,	100,000	25,000
Average of	twenty samples,	. . . .	104,800	26,675

Allowing for eleven per cent difference between processes of crushing between steel-plates and between wooden cushions, this gives an average for Minnesota granites of 23,318 pounds.

<sup>1</sup> Estimated.

<sup>2</sup> Probably imperfect sample.

The following are the records of tests of New-England granites:—

Kind of stone.	Location of quarry.	Position.	Strength in pounds.	
			Of sample.	Per cubic inch.
Blue . . .	Staten Island, N.Y. . .	On bed .	89,250	22,315
	Fox Island, Me. . .	- -	59,500	14,875
	Dix Island, Me. . .	- -	60,000	15,000
Dark . . .	Quincy, Mass. . .	- -	71,000	17,750
Light . . .	Quincy, Mass. . .	- -	59,000	14,750
Flagging . . .	Hudson River, N.Y. . .	- -	53,700	13,425
	Cape Ann, Mass. . .	On bed .	59,750	14,937
Porter's rock,	Mystic River, Conn. .	On bed .	72,500	18,125
Gray . . .	Stony Creek, Conn. .	On bed .	60,000	15,000
Gray . . .	Fall River, Mass. . .	On bed .	63,750	15,937
Bluish-gray .	Keene, N.H. . .	On bed .	41,000	10,250
Bluish-gray .	Keene, N.H. . .	On bed .	51,500	12,875
	Millstone Pt., Conn. .	- -	64,750	16,187
	Greenwich, Conn. . .	- -	45,200	11,300
Niantic river,	New London, Conn. .	- -	50,000	12,500
Niantic river,	New London, Conn. .	On edge,	56,700	14,175
	Vinalhaven, Me. . .	- -	52,600	13,150
	Vinalhaven, Me. . .	- -	67,000	16,750
	Westerly, R.I. . .	On bed .	58,750	14,689
	Westerly, R.I. . .	On edge,	59,750	14,937
Average of	twenty granites . . .	. . . .	59,785	14,946

After discussing several supposable causes of error, and showing that they could not have applied to the present case, the author proceeds to suggest causes why the Minnesota granites may be stronger than those of New England. He thinks those of the west may have been less changed by decay. The lateness of the glaciation to which they were exposed may have left them comparatively fresh through the recent removal of a considerable thickness. On this point we shall be more certain when the glacial moraines have been fully traced from east to west, and the western analogues are determined.

#### The singing beach of Manchester, Mass.

BY A. A. JULIEN OF NEW YORK AND H. C. BOLTON OF HARTFORD, CONN.

SANDS were taken from the so-called 'singing beach' on the coast of Massachusetts, near Manchester-on-the-Sea, and subjected to microscopical examination. In this beach, the felspathic rocks are intersected by numerous dykes of igneous rocks, among which porphyritic diorite is noticeable. The phenomenon which gives rise to the name of the beach is confined to the portion of sand lying between the water-line and the loose sand above the reach of ordinary high tide. Portions emit the sound; but closely contiguous areas fail to do so, or answer feebly. The sound is near the surface; at the depth of one or two feet it ceases, perhaps because of moisture. The sound is produced by pressure, and may be likened to a subdued crushing; it is of low intensity and pitch, is not metallic nor crackling. It occurs when the sand is pressed by ordinary walking, increases with sudden pressure of the foot upon the sand, and is perceptible upon mere stirring by the hand, or even plunging one finger and removing it suddenly. It can be intensified by dragging wood over the beach.

The authors review and cite very fully the literature of the subject, giving in full a description of the singing sands of the island of Kauai, one of the Hawaiian group. That gives a sound as of distant thunder, when any thing of weight is dragged over it. Dampness prevents the sound. That sand is calcareous. Hugh Miller cites similar instances at Jebel Nakous in Arabia Petrea, and Reg Rawan near Cabul. Those are silicious sands. The sounds were a sort of humming.

In Churchill county, Nevada, a similar phenomenon is described with regard to a sand-hill, as like the sound of telegraph-wires when wind blows them.

The authors also review and characterize the various sands of different mineral origin.

To explain the sonorous peculiarity of the sand, several theories are considered. That of equality, or of the unequal size of the grains, is rejected. Cellular structure has been supposed, but is not found in the present instance. Effervescence of air between moistened surfaces does not apply to this case. Sonorous mineral, such as clinkstone, is not present. There is no evidence of electrical phenomena being concerned. The hypothesis adopted is that the sand, instead of being, as ordinarily, composed of rounded particles, is made up of grains with flat and angular surfaces. In the present instance, the plane surface of felspar is apparent in many of the grains. Probably a certain proportion of quartz and felspar grains is adapted to give the sound, while less or more of either component would fail of the result.

Dr. Bolton has himself examined a sand of similar quality, on the island of Eigg in the Hebrides, and has described its properties. That is largely calcareous. Its constitution is a mixture of large and small grains, the larger ones being rounded quartz. Many small, angular fragments of quartz are also contained, and many dark granules of chert, the last being about three or four per cent of the whole, and having a cellular structure.

It is concluded, that the sound is produced either by the intermixture of grains having cleavage planes, or of grains with minute cavities. The paper ends with a table of the physical structure of the sands of many localities.

#### (PALEONTOLOGICAL PAPERS.)

#### Preliminary note on the microscopic shell-structure of the paleozoic Brachiopoda.

BY JAMES HALL OF ALBANY, N.Y.

IN the earlier studies of the Brachiopoda, the numerous species were referred to few generic terms, determined from their perforated apex and external form, and later from the study of the interior as these became known. The author said, that from time to time, as these characters had become known to him from the study of large collections, he had found it necessary to propose the separation of eighteen new generic forms from those previously known in this class of fossils. Other authors had also proposed new generic terms, until the list had become many times greater than it was twenty-five years ago.

While the interior structure of the hinge, and the muscular and vascular markings, were now pretty well known for most of the generic forms in use, comparatively little attention had been given to the minute structure of the shell. Little more had been done than to show that some forms possessed a punctate and others a fibrous texture.

The study of this structure had been commenced by him many years ago, but he had been thwarted in his efforts to procure the required cutting and polishing of specimens of the shells for microscopic study. He had now been able to obtain such thin slices of the shell as were required for this purpose, and had already several hundred slides prepared for the microscope.

A few of these only were shown, exhibiting the shell structure of as many genera. A considerable number of photographs had been made, illustrating, in a very satisfactory manner, the minute structure of each one, enlarged to twenty diameters. The photographs exhibited were illustrations of several species of *Orthis*, *Leptaena*, *Strophomena*, *Strophodonta*, *Chonetes*, etc.

The study of this shell-structure has shown very satisfactorily, what was partially known before, that the genus *Orthis*, as now defined and constituted, includes very heterogeneous material. External form, hinge characters, and interior muscular impressions, have been the chief guide; and yet forms have been included under this genus, showing widely different muscular markings. On further microscopic study, it has been found that these differences in form of muscular imprints are accompanied by important differences in the shell structure.

These differences may be noted in the illustrations presented, where the shell of *Orthis biforata*, *O. borealis*, *O. tricenaria*, *O. occidentalis*, *O. flabella*, are non-punctate and coarsely fibrous. *Orthis* (?) *strophomenoides* is, like *Streptorhynchus*, fibrous. *Orthis subquadrata* has, like *O. occidentalis*, a few large punctae.

In the second group, *Orthis testudinaria*, *O. Vanuxemi*, *O. perveta*, *O. penelope*, *O. elegantula*, *O. clytie*, and *O. hybrida*, have one or more rows of punctae to each ray, the rows well defined, and the intermediate shell finely fibrous.

The third group, consisting of *Orthis multicostata* of the lower Helderberg, *O. jowensis* of the Hamilton group, *O. tulliensis* of the Tully limestone, *O. impressa* of the Chemung group, are highly punctate with a fine fibrous texture of the shell substance.

The punctae usually come out along the summits of the radiating striae or plications of the shell. In some species the minute tubes perforating the shell, and producing these punctae, bifurcate and diverge before coming to the external surface of the shell.

This difference in shell structure, in forms known as *Orthis*, will require a separation of the species into groups based upon the shell structure, and character of muscular impressions. Already we see that the shells of compact fibrous texture have a form of muscular impression quite unlike those with the punctate structure; and we shall probably find that all

the interior modifications of the muscular system are accompanied by differences in the microscopic structure.

This method of determining the shell structure, in cases where the specimens may be imperfect, and thereby enabling the determination of obscure or fragmentary material, and its geological relations, will be of much importance to the geologist.

The structure of the shell in *Strophomena* is closely fibrous, with distant large punctae. In *Strophodonta*, the punctae are more numerous. In *Chonetes*, the punctae are large, and arranged parallel to the radii, having a pustulose aspect.

In many other forms, the punctate texture of the shell is characteristic, and of importance in the determination of the generic forms.

The physiological significance of this peculiar shell structure will be considered upon some future occasion, illustrated by more numerous examples.

### Rhizocarps in the paleozoic period.

BY J. W. DAWSON OF MONTREAL, CAN.

THE author referred to a previous memoir, entitled 'Spore-cases in coal,' published in 1871. This described fossil remains in a shale from the Erian formation at Kettle Point, Lake Huron, supposed to be on the horizon of the Marcellus shale of New York. The remains are minute brownish discs scarcely more than one-hundredth of an inch in diameter. They were recognized as probably spore-cases or macrospores of some acrogenous plant. The shale also contains vast numbers of granules, which may be escaped spores or microspores. In 1882 Dr. Dawson's attention was called to the discovery of similar bodies in vast numbers in the Erian and lower carboniferous shales of Ohio. The discoverer, Professor Orton, regarded these bodies as spore-cases, and as the chief source of the bituminous matter in those shales. Professor Williams found similar bodies in the Hamilton shales of New York; and Prof. J. M. Clarke, in the Genesee shale and in the corniferous limestone. The last named are of larger size than the others.

No certain clew had been thus far afforded to the affinities of these widely distributed bodies. But last March, specimens were found in the Erian formation of Brazil, by Mr. Orville Derby, which threw new light on the subject, containing as they did, along with the *Sporangites*, abundant fronds of *Spirophyton*. The *Sporangites* of Brazil resemble in every respect the involucre or spore-sacs of modern rhizocarps, and especially the sporocarps of the genus *Salvinia*.

Dr. Dawson describes with technical exactness two leading types which he has named provisionally *Sporangites braziliensis* and *S. bilobatus*. The paper offers the suggestion that these plants, now so insignificant, culminated in the paleozoic age, and, occupying the submerged flats of that period with abundant vegetation, produced a great quantity of the bituminous matter found in resulting beds. A rich rhizocarpean vegetation in the early paleozoic and

eozeic ages may have preceded the great development of acrogens in the later paleozoic.

In the discussion which followed, Dr. Dawson disclaimed any intention to assert that the *Sporangites* were the sole source of the bituminous matter.

### **Rensselaeria and a fossil fish from the Hamilton group of Pennsylvania.**

BY E. W. CLAYPOLE OF NEW BLOOMFIELD, PENN.

THE Hamilton sandstone of Pennsylvania is found in ridges just before we come to the Blue Mountains. The sand tapers off from a centre in these ridges both ways. At places it is eight hundred feet in thickness, some of it quite hard and flinty. Perhaps this sand was left by rivers; but, at all events, where it is missing it must have been cut away by erosion. The author believed that an ancient river had occupied nearly the place of the present Susquehanna, but running in an opposite direction,—to the north,—and probably debouching where the city of Harrisburg now stands. That locality had previously been below the sea: it was raised so as to become dry land through which this river runs. That land and that river again sank slowly. Then the sunken land received sand from the river. Afterward this region became the bed of a sea. It is a fan-shaped deposit, thickening toward the centre of the fan.

The author exhibited a model of a fish whose remains were discovered in this sandstone. He also showed specimens of alleged *Rensselaeria* found in the Hamilton sandstone. The latter were shown to Prof. James Hall, during the reading of the paper. Mr. Claypole thought them identical with the *Rensselaeria* of the Oriskany sandstone, there being a difference of a thousand feet between the two horizons; and he believed this the first instance of such discovery. The strata were tilted on edge in the locality where the fossils were found. Mr. Claypole made a diagram of the geological structure of the region. The fossils were in the middle of the sandstone, which is six hundred to eight hundred feet thick. A *Spirifer* very much like *S. formosa* is found there in great quantities.

Professor Hall, after a brief examination, said that anybody was excusable for supposing the fossils to be *Rensselaeria*. The differences between them and the Oriskany fossil were slight though well marked. Professor Hall described some of these differences, and Mr. Claypole acknowledged that a certain V-shaped groove was wanting in his specimens. Professor Hall thought that possibly the fossils should be referred to *Amphigenia*, which had many similarities to *Rensselaeria*. Professor Newberry thought the fish fossil new.

### **A large crustacean from the Catskill group of Pennsylvania.**

BY E. W. CLAYPOLE OF NEW BLOOMFIELD, PENN.

OF this fossil the author exhibited a cast. It showed no evidence of fish structure. Its apparent affinities were with the king crab, yet it was not a

true *Limulus* nor even a limuloid. A cast in gutta-percha was also shown, which better exhibited the markings. There was a resemblance in the fine surface-marks to *Eurypterus*. But the eurypterids, with a single exception, were all found in strata vertically distant six thousand feet.

Professor Hall said that the eurypterids were widely distributed. They were found in the coal-measures, in the Waverly sandstone, and perhaps—though that was not quite certain—in the Portage group.

### **Animal remains from the loess and glacial clays.**

BY WILLIAM MCADAMS OF ALTON, ILL.

THE drift clays proper at Alton, Ill., had a maximum thickness of about one hundred feet, and the bluff clays were nearly of the same thickness. These clays were remarkably rich in animal remains, such as teeth and bones, attached to calcareous nodules or claystones. Remains of thirteen different species, now perhaps all extinct, had been found. The rodents were well represented in the bones of seven species, including three or more beavers and some gophers. Nearly seventy teeth were found in the quaternary deposits, a majority of them in a single quarry.

### **A new vertebrate from the St. Louis limestone.**

BY WILLIAM MCADAMS OF ALTON, ILL.

ONE of the groups of subcarboniferous limestone is quarried extensively near Alton and St. Louis. It lies beneath the coal, and in some places the coal rests directly upon it. A number of vertebrate remains have been found in one of the quarries near Alton. Specimens were shown by the author of the paper. In the judgment of Professor Newberry, the fossils shown were the bones of some large fish. One appeared to be the mandible or dental bone of the lower jaw. Without pronouncing a final opinion, he would say that it bore a general resemblance to a group of fossil fishes in which the teeth were inserted in sockets; but the animal itself was large and hitherto unknown.

### **List of other papers.**

The following additional papers were read in this section, some of them by title only: Thermal belts, by *J. W. Chickering*. The Hamilton sandstone of middle Pennsylvania, by *E. W. Claypole*. Evidences from southern New England against the iceberg theory of the drift, by *J. D. Dana* [this paper will appear in full in *SCIENCE*]. Topaz and associated minerals from Stoneham, Oxford county, Me.; Colored tourmalines and lepidotite crystals from a new American locality; A note on the finding of two American beryls; Andalusite from a new American locality; On a white garnet from near Hull, Canada,—by *G. F. Kunz*. The genesis and classification of mineral veins, by *J. S. Newberry*.